§12. Role of Electron Dynamics in Intermittent Collisionless Driven Reconnection

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We have analyzed an intermittent behavior in collisionless driven reconnection by making use of a newly developed two-dimensional electromagnetic full particle simulation code for an open system, in which an external driving electric field is assumed at the upstream boundary and free boundary conditions are adopted at the downstream boundary.

When the input window size x_d increases twofold ($x_d = 36\rho_i$), the system reveals a quite different behavior from the narrow window case ($x_d = 18\rho_i$). An elongated current sheet along the x-axis is created as a result of the plasma compression over a relatively long range for the wide window case. The length of the current sheet is roughly estimated as $L_{cs} \approx 10\rho_i$. This means that the current sheet becomes unstable against a collisionless tearing instability. Magnetic islands are frequently created at the center of current sheet through an electron tearing instability, as is shown in Fig. 1. In the wide window case, the system never reaches the steady state with a single reconnection point and a constant reconnection rate.

Figure 2 is the time history of three spatial scales in the current sheet. The width of the current layer d_{jz} changes between the ion meandering scale l_{mi} and the electron meandering scale l_{me} in the wide window case. When a magnetic island starts to grow in the neutral sheet, the reconnection field exceeds the driving field ($E_{rec} > E_0 = 0.04$, see dashed line in Fig. 3) and the width decreases below the ion scale toward the electron scale. The width returns to the ion scale from the electron scale after an island moves away from the central region.

Figure 3 illustrates the temporal evolutions of reconnection electric field and effective resistivity at reconnection point where the effective resistivity is defined as the ratio of the electric field to the current density. The effective resistivity increases in accordance with the growth of magnetic islands and returns to a small value when an island moves away from the central region. It is also found that the electron trapping inside magnetic islands leads to the increase in the electric current and thus the growth of magnetic islands. It is concluded that an intermittent behavior in collisionless driven reconnection is controlled by the electron dynamics.

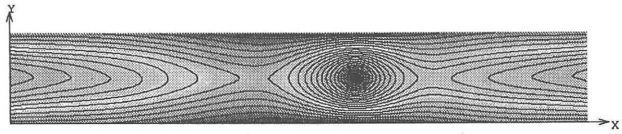

Fig. 1. Contour plots of vector potential $A_z(x, y)$ at $t\omega_{ce} = 755$.

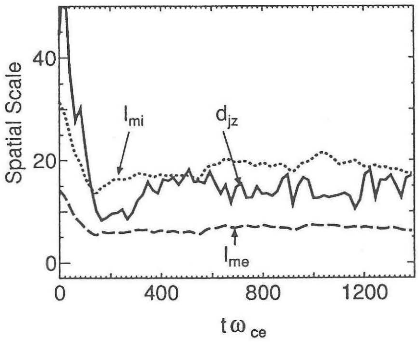

Fig. 2. Temporal evolutions of three spatial scales in the current sheet for $x_d = 36\rho_i$.

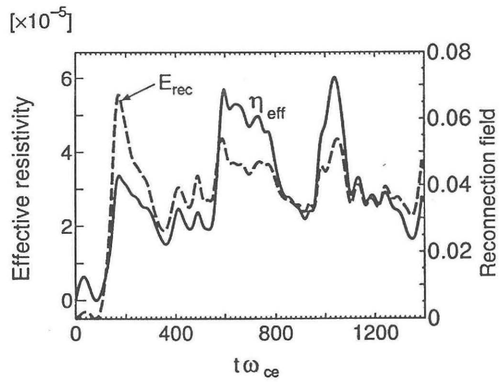

Fig. 3. Temporal evolutions of reconnection electric field and effective resistivity at reconnection point where the diving electric field is $E_0 = 0.04$.

References
1) R. Horiuchi, W. Pei and T. Sato, Earth, Planets, and Space, in press, 2001.
2) W. Pei, R. Horiuchi and T. Sato, Phys. Plasma, in press, 2001.